

Department of Chemistry and Biochemistry

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Undergraduate Advisors:

Faculty advisors in the Department of Chemistry and Biochemistry are as follows:

Ann E. Aust, Widtsoe 233, (435) 797-1629, aaust@cc.usu.edu

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For faculty advisor assignment, contact Department of Chemistry and Biochemistry at (435) 797-1619 or chemist@cc.usu.edu.

Degrees Offered: Bachelor of Science (BS), Bachelor of Arts (BA), Master of Science (MS), Doctor of Philosophy (PhD) in Chemistry; MS and PhD in Biochemistry; BS and BA in Chemistry Teaching; BS and BA in Composite Teaching— Physical Science (Chem)

Undergraduate emphases: BS—Professional Chemistry, Biochemistry, Environmental Chemistry, Chemical Education, Life Science

Graduate specializations: *Chemistry*—Analytical Chemistry, Inorganic Chemistry, Organic Chemistry, Physical Chemistry

Undergraduate Programs

Objectives

Chemistry is a subject that addresses the properties of materials and the transformations that they undergo. Especially important are aspects of energy and structure related to chemical reactivity. Consequently, students of many disciplines take courses in chemistry to learn about the behavior of the substances they will use or reference. The Department of Chemistry and Biochemistry offers a wide variety of courses for those whose majors and/or anticipated careers require a knowledge of chemistry. These areas of study include nutrition, engineering, biology, agriculture, natural resources, medicine, law, and education, to name a few. Many students also choose chemistry as an elective course to better prepare themselves as citizens in a technological world.

The **Bachelor of Science Degree** entails considerable specialization in chemistry and related areas. The BS emphases require a common core of courses, but allow for a different concentration of advanced work according to the interests and career objectives of the student. The **BS with Professional Chemistry Emphasis**, **BS with Environmental Chemistry Emphasis**, and **BS with Biochemistry**

Emphasis degrees meet the requirements for certification by the American Chemical Society (ACS). The certified degree emphases provide excellent preparation for immediate entry into the job market or for graduate school in chemistry, biochemistry, chemical engineering, molecular biology, nutrition, food science, materials science, and a wide variety of other fields. ACS certification in **Chemical Education** is available to students who complete an ACS-certified program, together with the Professional Education program in secondary education. The **BS with Life Science Emphasis** degree is popular for students wishing to go on to medical or dental graduate programs. The life science emphasis is particularly appropriate for **premedical** and **predental** students who want a strong base for understanding the nature of chemical reactions in the body and the behavior of the drugs they will prescribe, or who want an attractive alternative should they decide ultimately not to pursue medical or dental school. The **Chemistry Teaching Major** or the **Composite Teaching Major in Physical Science** are available to those who want a career in secondary education. The BA degree is an excellent choice for students with an interest in studying **law** or **business** and who have an interest in science.

The core of the program utilizes year-long sequences of classes. The first-year sequence introduces the basic principles of chemistry, as well as most of the major concepts of the science. The second year explores in greater depth the characteristics of carbon-based compounds that serve as the backbone for the chemistry of life; for most drugs and medicines; for petroleum; for most fibers, paints, and plastics; and for many other commercial products. The third year examines in greater depth the models, theories, and mathematical interpretation of the structures, rates of change, energetics, and other properties of chemicals. In addition, one-semester courses examining the chemistry of life processes, the behavior of inorganic substances, and the analysis of the composition of substances are required. Many of the sequences have associated laboratory courses where students get hands-on practice. Here they synthesize compounds, measure physical properties, analyze samples, and determine structural features of compounds, using modern techniques and instrumentation. The requirements of the BS and BA degrees in chemistry, along with University and University Studies requirements, are summarized here. The specific requirements for the teaching major and for the composite teaching major in physical science are also included.

Students are also urged to study these requirements and to visit with their advisor on a regular basis about progress toward the completion of their degrees or for any questions regarding complementary courses and career goals.

Assessment

The Department of Chemistry and Biochemistry has implemented a multilayered assessment strategy that defines learning objectives at the following levels: individual courses, divisional levels, and at the overall program level for the chemistry major. Details of this strategy can be found at: <http://www.chem.usu.edu/assessment/index.php>

Learning objectives for the Chemistry Major are specifically outlined in an organized matrix at: <http://www.chem.usu.edu/assessment/matrix.pdf>

General Requirements

Admission Requirements

First-year students admitted to USU in good standing qualify for admission to this major. Transfer students from other institutions

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need a 2.2 transfer GPA, and students transferring from other USU programs need a 2.0 total GPA for admission to this major in good standing.

Students interested in studying chemistry should take high school mathematics courses that will enable them to start calculus during their first semester at USU. High school coursework in chemistry and physics is also desirable. AP credit in chemistry may be counted toward the degree. For details, contact the departmental advising faculty.

No CHEM prefix course may be applied toward graduation with any major or minor in chemistry with an earned grade of less than C-. Except for CHEM 4800 and 4990, no CHEM prefix course may be taken on a *Pass/Fail* basis. No CHEM prefix course may be repeated more than one time to improve the grade to a C- or better. A student dropped from the chemistry program for failure to meet this standard may appeal to the departmental Curriculum Committee for readmission.

Chemistry Core Curriculum

In addition to the University Studies requirements for graduation, chemistry majors take a series of core courses spread across a traditional four-year period. The completion of the chemistry core also covers the College of Science requirements for graduation.

Chemistry Major Core Requirements

Suggested Schedule

First Year (30-32 credits)

Fall Semester (15-16 credits)

CHEM 1210 Principles of Chemistry I	4
CHEM 1230 Chemical Principles Laboratory I	1
MATH 1210 (QL) Calculus I	4
University Studies Courses	6-7

Spring Semester (15-16 credits)

CHEM 1220 (BPS) Principles of Chemistry II	4
CHEM 1240 Chemical Principles Laboratory II	1
MATH 1220 (QL) Calculus II	4
University Studies Courses	6-7

Second Year (32-33 credits)

Fall Semester (16 credits)

CHEM 2310 ² Organic Chemistry I	4
CHEM 2330 Organic Chemistry Laboratory I	1
CHEM 3600 (QI) Quantitative Analysis	3
CHEM 3610 Quantitative Analysis Laboratory	1
PHYX 2210 (QI) General Physics–Science and Engineering I	4
MATH 2210 (QI) Multivariable Calculus	3

Spring Semester (16-17 credits)

CHEM 2320 ³ Organic Chemistry II	4
CHEM 2340 Organic Chemistry Laboratory II	1
CHEM 3510 Intermediate Inorganic Chemistry	2
CHEM 3520 Inorganic Chemistry Laboratory	1
PHYX 2220 (QI/BPS) General Physics–Science and Engineering II	4
University Studies Courses	4-5

Third Year (29-31 credits)

Fall Semester (14-16 credits)

CHEM 3060 (QI) ² Physical Chemistry	3
CHEM 3080 (CI) ² Physical Chemistry Laboratory I	1
CHEM 5700 ² General Biochemistry I	3
MATH 2250 (QI) ¹ Linear Algebra and Differential Equations (4 cr) or	

STAT 3000 (QI) ¹ Statistics for Scientists (3 cr)	3 or 4
University Studies or elective courses	4-5

Spring Semester (15 credits)

CHEM 3070 (QI) ³ Physical Chemistry	3
CHEM 3090 (CI) ³ Physical Chemistry (Laboratory II)	1
CHEM 5640 ³ Instrumental Analysis	3
CHEM 5650 ³ Instrumental Analysis Laboratory	2
University Studies or elective courses for specific degree emphasis	6

Fourth Year (31-32 credits)

CHEM 4990 (CI) Undergraduate Seminar	2
Upper-division and advanced elective courses for specific degree emphasis	29-30

¹ The completion of MATH 2250 or STAT 3000 is optional for the Teaching Major.

Chemistry Degree Emphases

Professional Chemistry Emphasis (ACS Certified)

In addition to the chemistry core, students must complete the following:

CHEM 5520 ² Advanced Inorganic Chemistry (F)	2
CHEM 5530 ³ Advanced Synthesis Laboratory (Sp)	2
Advanced electives as approved by department	6

Biochemistry Emphasis (ACS Certified)

In addition to the chemistry core, students must complete the following:

CHEM 5710 ³ General Biochemistry II (Sp)	3
CHEM 5720 ³ General Biochemistry Laboratory (Sp)	2
BIOL 1210 ² Biology I (F)	4
Advanced Biology electives, as approved by department	4

Environmental Chemistry Emphasis (ACS Certified)

In addition to the chemistry core, students must complete the following:

CHEM 5670 ³ Intermediate Environmental Chemistry (Sp)	3
CHEM 5680 ³ Environmental Chemistry Laboratory (Sp)	2
Introductory environmental electives as approved by department	6-7
Advanced environmental electives as approved by department	3

Chemical Education Emphasis (ACS Certified)

Note: Beginning in 2006, all USU teacher education candidates will be required to take and pass the content exam approved by the Utah State Office of Education in their major content area prior to student teaching.

In addition to the chemistry core, students must complete the following:

Required courses for the Secondary Teacher Education Program (STEP)	35
Teaching minor from outside the Department of Chemistry and Biochemistry	12-16

² Offered fall semester only

³ Offered spring semester only

BS Degree with Honors

This option can be met by completing any ACS certified program and by meeting the following requirements:

1. Minimum GPA of 3.50 in chemistry courses
2. Overall GPA of 3.30

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3. Completion of 15 credits of honors work as follows:

CHEM 4800H (CI) Research Problems (F, Sp, Su).....	3-6
CHEM 4990H (CI) Undergraduate Seminar (F, Sp)	2
Credits selected from Honors courses numbered 3000 or above in chemistry or related subjects, as appropriate. Three credits may be selected from chemistry courses numbered 6000 or above.....	
	3-6

In addition, select two courses from the following:

CHEM 2320H Organic Chemistry II (Sp).....	4
CHEM 3070H (QI) Physical Chemistry (Sp).....	3
CHEM 5640H Instrumental Analysis (Sp)	3
CHEM 5700H General Biochemistry I (F)	3

BS in Chemistry, Life Science Emphasis

In addition to the Chemistry Core Requirements (with the exception of CHEM 5640, 5650), students must complete the following:

BIOL 1210 Biology I (F).....	4
BIOL 1220 (BLS) Biology II (Sp) (4 cr) or	
BIOL 2000 Human Physiology (F,Sp,Su) (4 cr).....	4
BIOL 3200 (QI) Principles of Genetics (F,Sp,Su) (4 cr) or	
BIOL 3300 (BLS) General Microbiology (F,Sp) (4 cr)	4
CHEM 5710 General Biochemistry II (Sp).....	3
CHEM 5720 General Biochemistry Laboratory (Sp)	2

BA in Chemistry

In addition to the chemistry core (with the exception of CHEM 5640, 5650), students must complete the following:

CHEM 5520 Advanced Inorganic Chemistry (F) (2 cr) or	
CHEM 5640 Instrumental Analysis (Sp) (3 cr).....	2 or 3
Completion of one foreign language (16 cr) or	
Completion of two foreign languages (20 cr).....	
	16 or 20

Chemistry Teaching Major

In addition to the Chemistry Core Requirements (with the exception of MATH 2250 or STAT 3000, and CHEM 5640 and 5650), students must complete the following:

SCI 4300 Science in Society (F,Sp)	2
Required courses for the Secondary Teacher Education Program (STEP).....	
	35
Teaching minor from outside the Department of Chemistry and Biochemistry	
	12-16

An overall 2.75 GPA in a minimum of 60 semester credits of approved University coursework is required for admission into the Secondary Teacher Education Program (STEP). A minimum overall GPA of 2.75 is required for graduation. Specific for admission to this program, a student must have at least a 2.75 GPA in CHEM 1210, 1220, 1230, and 1240.

Composite Teaching Major in the Physical Sciences

This degree is available through the Chemistry and Biochemistry or Physics departments. Students with a Composite Teaching Major in Physical Sciences should plan their programs carefully in order to meet the upper-division requirement for graduation. An overall 2.75 GPA in a minimum of 60 semester credits of approved University coursework is required for admission into the Secondary Teacher Education Program (STEP). A minimum overall GPA of 2.75 is required for graduation. Students who may wish to teach Integrated Science at the middle or junior high school level should talk to their advisor about completing the courses necessary for an Integrated Science endorsement.

Note: Beginning in 2006, all USU teacher education candidates will be required to take and pass the content exam approved by the Utah State Office of Education in their major content area prior to student teaching.

Specific for admission to this program, a student must have at least a 2.75 GPA in the following chemistry and physics courses:

CHEM 1210 Principles of Chemistry I (F,Sp)	4
CHEM 1220 (BPS) Principles of Chemistry II (F,Sp,Su)	4
CHEM 1230 Chemical Principles Laboratory I (F,Sp)	1
CHEM 1240 Chemical Principles Laboratory II (F,Sp)	1

PHYX 2110 The Physics of Living Systems I (4 cr) **and**
PHYX 2120 (BPS) The Physics of Living Systems II (4 cr).....

OR
PHYX 2210 (QI) General Physics–Science and Engineering I
(4 cr) **and**
PHYX 2220 (QI/BPS) General Physics–Science and Engineering II
(4 cr)

(PHYX 2210 and 2220 are preferred.)
This program does not include many aspects of the Chemistry Core.

Required Courses:

CHEM 1210 Principles of Chemistry I (F,Sp)	4
CHEM 1220 (BPS) Principles of Chemistry II (F,Sp,Su)	4
CHEM 1230 Chemical Principles Laboratory I (F,Sp)	1
CHEM 1240 Chemical Principles Laboratory II (F,Sp)	1
CHEM 2300 Principles of Organic Chemistry (F) (3 cr) or	
CHEM 2310 Organic Chemistry I (F) (4 cr)	3 or 4
CHEM 2330 Organic Chemistry Laboratory I (F)	1
PHYX 1000 (BPS) Introductory Astronomy	3
PHYX 1030 (BPS)⁴ Intelligent Life in the Universe (3 cr) or	
PHYX 3030 (DSC/QI) The Universe (3 cr)	3

PHYX 2110 The Physics of Living Systems I (4 cr) **and**
PHYX 2120 (BPS) The Physics of Living Systems II (4 cr).....

OR
PHYX 2210 (QI) General Physics–Science and Engineering I
(4 cr) **and**
PHYX 2220 (QI /BPS) General Physics–Science and Engineering II
(4 cr)

MATH 1210 (QL) Calculus I (F,Sp,Su)	4
MATH 1220 (QL) Calculus II (F,Sp,Su)	4
STAT 3000 (QI) Statistics for Scientists (F,Sp).....	3
SCI 4300 Science in Society (F,Sp)	2
BIOL 1010 (BLS) Biology and the Citizen (F,Sp,Su).....	3
GEO 1150 (BPS) The Dynamic Earth: Physical Geology (F,Sp).....	4
BMET 2000 (BPS) The Atmosphere and Weather (F,Sp)	3
Teacher licensure courses from Secondary Education (35 cr).....	
	35
A teaching minor is optional for the Composite Teaching Major in the Physical Sciences.	

⁴PHYX 1030 is sometimes listed as USU 1360, ST: Intelligent Life in the Universe.

Chemistry Minor

In addition to CHEM 1210, 1220, 1230, and 1240, 10 additional credits in Chemistry prefix courses at the 2000 level or higher, as approved by department, are required (either CHEM 2300 or 2310 may be included).

Chemistry Teaching Minor

In addition to CHEM 1210, 1220, 1230, 1240, CHEM 2300 or 2310, and CHEM 2330, 3-4 additional credits selected from the following are required:

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CHEM 2320 Organic Chemistry II (Sp) (if CHEM 2310 has been previously selected)	4
CHEM 3060 (QI) Physical Chemistry (F)	3
CHEM 3510 Intermediate Inorganic Chemistry (Sp) (2 cr) and	
CHEM 3520 Inorganic Chemistry Laboratory (Sp) (1 cr)	3
CHEM 3600 (QI) Quantitative Analysis (F)	3
CHEM 3650 (DSC) Environmental Chemistry (Sp) (3 cr) or	
CHEM 3700 Introductory Biochemistry (Sp) (3 cr)	3

Undergraduate Research Opportunities

The Chemistry and Biochemistry Department encourages students in all departmental majors to engage in undergraduate research. For information about how they can become involved in undergraduate research, students should contact Joan Hevel, the departmental undergraduate research coordinator, (435) 797-1622, jhevel@cc.usu.edu.

Career Opportunities

Chemistry degree holders work in a wide variety of professions, from physicians, lawyers, and professors to research/development, sales, or production in the chemical, oil, pharmaceutical, metals, electronic, and biochemical industries. Government at all levels employs chemists, including the federal Departments of Defense, Health and Human Services, Agriculture, and Interior. A graduate with a bachelor's degree often begins work in chemical analysis or sales or may assist senior chemists in research and development. A graduate with a teaching major or chemistry education emphasis may teach in public schools. A graduate degree is usually needed to direct research or teach at the university level. Degree holders from the Department of Chemistry and Biochemistry have had excellent success in obtaining support for graduate studies, often at very prestigious institutions, and in obtaining employment directly following graduation. For further information, students should contact their advisor.

Departmental Honors

Students who would like to experience greater academic depth within their major are encouraged to enroll in departmental honors. Through original, independent work, Honors students enjoy the benefits of close supervision and mentoring, as they work one-on-one with faculty in select upper-division departmental courses. Honors students also complete a senior project, which provides another opportunity to collaborate with faculty on a problem that is significant, both personally and in the student's discipline. Participating in departmental honors enhances students' chances for obtaining fellowships and admission to graduate school. Minimum GPA requirements for participation in departmental honors vary by department, but usually fall within the range of 3.30-3.50. Students may enter the Honors Program at almost any stage in their academic career, including at the junior (and sometimes senior) level. The campus-wide Honors Program, which is open to all qualified students regardless of major, offers a rich array of cultural and social activities, special classes, and the benefit of Honors early registration. Interested students should contact the Honors Program, Merrill Library 374, (435) 797-2715, honors@cc.usu.edu. Additional information can be found online at: <http://www.usu.edu/honors/>

Additional Information

For more information about requirements for the majors and minors within the Chemistry and Biochemistry Department, see the Chemistry Major Requirement Sheet, available from the department, or online at: <http://www.usu.edu/ats/majorsheets/>

Graduate Programs

Admissions Requirements

See the general admission requirements for the School of Graduate Studies (pages 93-94). All applicants should have a bachelor's degree or master's degree in chemistry or biochemistry from an accredited institution. Appropriate undergraduate preparation is expected; applicants not fully prepared may be admitted with the condition that appropriate undergraduate courses are taken as necessary.

Applications are especially encouraged during the spring semester for expected admission in the following fall semester. However, the Graduate Recruiting and Admissions Committee screens applications throughout the year. Detailed information about the graduate programs and faculty research activities can be found on the Internet at: <http://www.chem.usu.edu>

Degree Programs

Master of Science

To earn an MS in chemistry or biochemistry, a student must meet the general requirements of the School of Graduate Studies (see pages 97-99), conduct research under the direction of a major professor and write a thesis acceptable to a supervisory committee (Plan A) or write a review-of-literature paper (Plan B), and pass an oral examination that is principally a defense of the thesis or the Plan B paper.

Qualified undergraduate chemistry majors at USU may apply in the third year for admission to the MS program. Students may be admitted to this MS program if they have a *B* average in chemistry, physics, and mathematics courses, and have completed the one-year sequences in general, organic, and physical chemistry (including labs), two courses in analytical or inorganic chemistry, two semesters of physics, math through MATH 2210, and at least 15 credits of their University Studies requirements.

Students should consult with the chairperson of the Graduate Recruiting and Admissions Committee to be certain of their eligibility for this program. The chairperson will then submit an application to the department head and to the School of Graduate Studies for approval. Students must earn a satisfactory score on the GRE exam before the completion of the MS degree. All requirements for the BS degree must be completed within two semesters of admission. The MS coursework cannot include coursework counted toward the BS degree.

Doctor of Philosophy

To earn the PhD in chemistry or biochemistry, a student must successfully complete a core curriculum of courses and other courses as approved by a supervisory committee. In addition, preliminary examinations (both oral and written) must be passed and research in a field of specialization must be conducted. The final requirement is the writing and defense of a dissertation before the student's supervisory committee.

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Biochemistry Course Requirements

Every MS and PhD student in the biochemistry program must complete at least four of the graduate biochemistry core courses (CHEM 6700, 6710, 6730, 6740, 6750, and 6760). In addition, all students must register for at least 2 credits of CHEM 6720 in the first semester of residence to participate in research training. Both MS and PhD students must complete a total of at least 15 credits in coursework, exclusive of seminar and research credit. The Program of Study is approved by the student's supervisory committee. A total of 30 credits is required for the MS degree, and a total of 90 credits is required for the PhD. Beginning students who already hold an MS degree need 60 credits to complete the PhD program.

Chemistry Course Requirements

Every MS and PhD student in the chemistry program must complete the courses required for their specialization: *Analytical*—CHEM 7600, 7610; *Inorganic*—CHEM 6500, 6510; *Organic*—CHEM 6300, 7300, 7310; or *Physical Chemistry*—CHEM 6010, 6020, 7020. Both MS and PhD students must complete a total of at least 15 credits in coursework, exclusive of seminar and research credit. The Program of Study is approved by the student's supervisory committee. A total of 30 credits is required for the MS degree and a total of 90 credits is required for the PhD. Beginning students who already hold an MS degree need 60 credits to complete the PhD program.

Financial Assistance

The department offers financial support to students in the form of teaching assistantships, research assistantships, and fellowships. All applications for admission to the School of Graduate Studies constitute an application for financial assistance; it is not necessary to file a separate request. Teaching assistantships are the principal means of support for first-year students. Inquiries about current support levels should be directed to the department main office. The department is responsible for the first nine months of stipend and tuition, with the remaining summer stipend and tuition usually being paid from faculty research funds. Teaching assistants devote no more than 12 contact hours per week directing undergraduate laboratories, leading recitation sections, and assisting students with questions during the regular fall and spring semesters. Research assistantships, funded from individual faculty research grants, support students conducting research related to the grant projects. Although first-year students are not normally supported as research assistants, well-prepared students may be eligible for research support at the discretion of their major professor.

Fellowships are awarded by the University to outstanding students solely on the basis of merit. The department encourages students with strong academic records to apply for the University fellowships and national awards, and will provide assistance in obtaining and submitting the appropriate forms. Additionally, several graduate awards are given each year to honor exemplary performance in research and teaching.

The College of Science recently established the Willard L. Eccles Foundation Science Fellowship. The \$18,000 per year, three-year stipend is competitively awarded to highly qualified science applicants. Students applying to the graduate program will be considered for this fellowship, and will be sent the necessary information. Application deadline for this fellowship is March 1.

Chemistry and Biochemistry Faculty

Trustee Professor

Ann E. Aust, biochemistry

Professors

Steven D. Aust, biochemistry

Stephen E. Bialkowski, analytical chemistry

Scott A. Ensign, biochemistry

David Farrelly, physical chemistry

Alvan C. Hengge, organic chemistry

Richard C. Holz, bioinorganic chemistry

Vernon D. Parker, physical organic chemistry

Steve Scheiner, computational chemistry

Lance C. Seefeldt, biochemistry

Professors Emeritus

William M. Moore, physical chemistry

Richard K. Olsen, organic chemistry

Grant G. Smith, organic chemistry

Jack T. Spence, inorganic chemistry

Associate Professors

Lisa M. Berreau, inorganic chemistry

Alexander I. Boldyrev, physical chemistry

Robert S. Brown, analytical chemistry

Bradley S. Davidson, organic chemistry

John L. Hubbard, inorganic chemistry

Assistant Professors

Cheng-Wei Tom Chang, organic chemistry

Joan M. Hevel, biochemistry

Philip J. Silva, analytical chemistry

Research Assistant Professor

Tapas Kar, physical chemistry

Lecturer

Douglas G. Harris

Course Descriptions

Chemistry and Biochemistry (CHEM), pages 476-478